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EXPERIMENTAL STUDY OF TURBULENT SPOTS.(U)

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Turbulent Spots; Laminar-Turbulent Transition; Flow Visualization; Growth by Destabilization.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A novel visualization technique that utilizes fluorescent dye excited by a sheet of laser light is employed to study turbulent spots evolving in an unstable laminar boundary layer. The large growth rates of the spot in the spanwise direction cannot be explained by classical entrainment. It is suggested that a new mechanism, termed "destabilization," accounts for the larger growth rates. Growth by destabilization appears to be the result of the turbulence inducing perturbation into the nearby unstable boundary layer. This disturbance grows and breaks down, thus forming the new turbulence in the spot.

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EXPERIMENTAL STUDY OF TURBULENT SPOTS

Annual Report

1 May 1980 - 30 April 1981

During the third year of the research program entitled "Experimental Study of Turbulent Spots," a major effort was directed towards understanding the *growth by destabilization* mechanism pointed out by Flow in the first phase of the investigation. More than two hundred experimental runs were conducted during this period. A new method for introducing the dye into the flow field was implemented, and proved invaluable in showing the details of the break-up process responsible for the lateral growth of turbulent spots.

The experiments were conducted in an 18 m towing tank. A flat plate was towed using an oil-lubricated carriage, and a laminar boundary layer evolved on the plate top surface. Turbulent spots were initiated by a solenoid valve that ejects a small amount of fluid through a minute hole on the flat plate. The flow field was made visible by introducing fluorescent dye and exciting it using sheets of laser light. A sheet of dye was introduced into the laminar boundary layer using a spanwise slot, and discrete lines of dye were introduced by masking the slot with electrical tape, in which minute longitudinal slots were cut using a surgical knife.

The experimental results showed that the spot grew normal to the plate by classical entrainment; and that it grew laterally by the growth by destabilization mechanism, which manifests itself as follows: the turbulent eddies within the spot appear to induce perturbations into the surrounding unstable laminar boundary layer which rapidly grow and breakdown, forming new turbulence, without ever being in direct contact with the older turbulence.

A new conceptual model for the turbulent spot was developed. The model has been described in two publications:

1. "The Growth of Turbulent Regions by the Destabilization Mechanism," Bulletin Am. Phy. Soc. 25, p. 1091, 1980.

2. "On the Growth of Turbulent Regions in Laminar Boundary Layers," J. of Fluid Mech., 1981 (in press).

In addition, the project team has presented seminars on the investigation results at the following institutions: University of Wisconsin, University of Washington; National Academy of Sciences; Washington State University; Naval Ocean Systems Center; Michigan State University; Ohio State University; the Massachusetts Institute of Technology; and two local meetings of the American Institute of Aeronautics and Astronautics.

Flow Research film No. 48 was produced and a copy was given to the technical monitor at AFOSR, Captain M. S. Francis.

During the coming year of this research project, we are planning to continue analyzing the experimental data collected this year. In addition, plans are underway to conduct hot-film probe measurements in the boundary layer. Two detection schemes for turbulent bursts and longitudinal vortices will be developed. The introduction of fast response probes and detection schemes for organized structures in turbulent flow fields will greatly increase our capabilities, and will undoubtedly lead to better understanding of turbulence and transition.